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DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

AERONAUTICAL RESEARCH LABORATORY

MELBOURNE, VICTORIA

Aircraft Structures Technical Memorandum 561

LAU-7/A MISSILE LAUNCHER STATIC AND DYNAMIC STRAIN SURVEYS

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T.J. VAN BLARICUM

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SUMMARY

This Technical Memorandum describes the results of static and dynamic strain surveys carried out on a LAU-7/A launcher (serial number NMH-230) as removed from a Royal Australian Air Force (RAAF) F/A-18 aircraft.

The launcher was tested with the original snubbing system and with an alternative aft hanger snubbing system developed by Hawker de Havilland Australia. The strain results from the two snubbing systems are compared.

DSTO AUSTRALIA

POSTAL ADDRESS: **Director, Aeronautical Research Laboratory**
506 Lorimer Street, Fishermens Bend 3207
Victoria Australia

CONTENTS

1.0 INTRODUCTION

A number of LAU-7/A launchers on Royal Australian Air Force (RAAF) F/A-18 aircraft had been found to have fatigue cracks in the guide rails at the forward missile hanger location. The LAU-7/A launcher supports the AIM 9L Sidewinder missile on the wingtips of the F/A-18. The fatigue cracking was observed to begin at low hours in service (200 to 600 flying hours) and was attributed to poor snubbing (locking in place on the launcher rail) at the aft missile hanger.

Previous ARL work to reinforce the front hanger

At the request of the RAAF, the Aeronautical Research Laboratory (ARL) was commissioned to develop a repair scheme to enable cracked launchers to be salvaged and returned to service. A repair was developed and fatigue tested (Ref. 1). That repair involved machining away the damaged rail section. A replacement rail section, consisting of a machined aluminium plate which restored the original rail profile was then bolted in place on the launcher. Implementation of the repair on a number of launchers in service on RAAF F/A-18 aircraft has proved to be successful to date.

Salisbury tests

Hawker de Havilland Australia (HDH) were commissioned by the RAAF to design an improved snubbing system that carried a greater share of the missile inertia loads at the aft hanger thereby preventing or reducing the incidence of cracking at the forward hanger location.

Vibration tests were carried out at the Defence Science and Technology Organization (DSTO) Vibration Laboratory at Salisbury, South Australia. Those tests used launcher serial number 422B fitted with a dummy Aim 9L missile. Launcher 422B was fitted with the HDH snubber. No strain gauges were fitted. The tests indicated that the HDH snubber did not prevent cracking of the launcher at the forward hanger location. The life to crack initiation was similar to that for RAAF F/A-18 aircraft usage. Fractographic analysis of the cracked launcher (No. 422B) by ARL has been reported previously (Ref. 2).

Recent ARL tests

To confirm the results of the Salisbury vibration tests and to obtain static strain data, ARL was requested by the RAAF to conduct dynamic and static strain surveys of an instrumented LAU-7/A launcher (serial number NMH-230) for both the original LAU-7/A and the HDH snubbing systems. This launcher was a cracked unit removed from an F/A-18 aircraft.

This Technical Memorandum describes the results and details of the tests carried out by ARL.

2.0 DESCRIPTION OF THE SNUBBING SYSTEMS

The original snubber design utilizes spring loaded wedges which produce a scissor action to push the aft AIM 9L missile hanger up against the inner faces of the launcher guide rail flanges.

The HDH snubbing system, unlike the original scissor action wedge system, was designed to hold the missile centrally between the launcher rails at the aft hanger location. Spring loaded pads hinge outwards to bear against the inside faces of the missile aft hanger bracket.

It should be noted that for the static and dynamic strain surveys carried out at ARL, the centre missile hanger (Fig. 1) was rotated from its normal position (i.e. engaged in the launcher guide rails) to be clear of the guide rails. This was done to prevent the transfer of any load to the centre hanger. It's uncertain how much load the centre hanger picks up in service.

3.0 LAUNCHER STRAIN GAUGING

The LAU-7/A launcher was instrumented with electric resistance strain gauges at the front and rear missile hanger locations as shown in Fig 1. All gauges were fixed to the guide rail flanges and were oriented transverse to the flange as shown.

Gauges 9 (a to j) to 16 (a to j) inclusive were pairs of strip gauges (Kyowa Type KFC-1-D9-23). Each strip gauge comprised 5 elements, and each element was a miniature strain gauge. Each pair of strip gauges was bonded with M Bond 200 cyano acrylate adhesive end to end onto the upper or lower launcher guide rail flange to form a 10 element gauge with individual elements labelled a to j inclusive.

Each strip gauge was arranged to give a measure of flange strain at locations from 6.475mm to 24.025mm from the edge of the flange in increments of 1.95mm (which is the pitch between the centres of successive elements of the ten element strip gauge).

In addition to the strip gauges, eight conventional gauges (Kyowa WA-13-125BT-120) were fitted to the guide rail flanges as shown in Fig. 1. These gauges were intended to give an overall measure of strain in the guide rail flanges. They were labelled 1 to 8 inclusive and were located with their centres 15mm from the edge of the guide rail flange.

4.0 TEST PROCEDURE

4.1 Static Strain Surveys

Figure 2 shows the launcher with a Dummy Air Defence Missile (DADM) fitted and mounted in the test rig. Load was applied to the DADM at its centre of gravity (C.G.) using a conventional hydraulic actuator and hand pump. The DADM aft and forward

hangers transferred the load applied to the missile into the launcher upper and lower rail flanges. The applied load was measured using an Interface brand load cell and a digital load cell read-out box calibrated to suit the load cell capacity.

The static calibration procedure was first carried out with the HDH snubber fitted to the launcher and then repeated with the original LAU-7/A snubber fitted.

The maximum up load applied was 8150 Newtons and the maximum down load applied was 6208 Newtons. Table 1 shows the load increments used.

Strain readings were taken at the 10% load increments up to 100% load for all gauges except for 9 (a to j) and 10 (a to j) at the forward hanger location. For these gauges, only elements d,e and f could be monitored due to a lack of channels on the ARL data acquisition system. It was regarded as more critical to monitor all gauges at the aft hanger location. Readings were taken during unloading at 70% and 40% load.

Data acquisition for the static strain surveys was via an ARL PC-based data acquisition system. Raw data in the form of loads and strains were processed after the tests using the spread sheet program "Quattro Pro" written by Borland Pty Ltd. The data output from "Quattro Pro" was in the form of a spread sheet of loads and strains, and plots of applied load versus strain gauge output (in microstrain), some of which are shown later in this report.

4.2 Dynamic Strain Surveys

The missile and launcher were held in the same rig as was used for the static strain surveys. A single sinusoidal excitation was used to vibrate the missile. The frequency was varied until resonant vibration was achieved in the region of 22Hz. Excitation frequency was then held constant at this resonance (24.5 Hz) and the amplitude of excitation adjusted to give a response of 2g RMS as measured by a reference accelerometer. The accelerometer was a Prodera brand piezo-electric type (0.5 volts/g) mounted on top of the missile 28cm aft of the point of intersection of the tail fin leading edges and the missile body.

The excitation signal was obtained from a Solartron digital Frequency Response Analyser. The excitation force was provided by a Ling 1000lb electromagnetic shaker attached to the missile 71cm ahead of the point of intersection of the tail fin leading edge and missile. Dynamic excitation force orientation was normal to the missile and corresponded to the vertical direction on the F/A-18 wing tip installation.

The RMS value of microstrain was measured at the strain gauges listed in Table 2. It should be noted that the output from strain gauges 14,15 and 16 elements g to j, could not be measured during the dynamic strain surveys, because the data acquisition system used did not have sufficient channels.

5.0 TEST RESULTS AND DISCUSSION

5.1 Static Strain Surveys

The results of the static strain surveys for 100% up and down loads are given in Table 3.

By inspection of these tables it can be seen that overall, the strain levels produced in the launcher guide rail flanges are low. The maximum strain recorded at 100% load was minus 555 microstrain for element i of strip gauge 14 (a to J).

Figures 3 to 8 inclusive are plots of the strip gauge data presented in Table 3 for the aft missile hanger location, i.e. gauges 11,12,13,14,15, ard 16.

Up Loading

Note that for up loading, generally only the gauges on the lower flange give significant response. (Vice versa for down loading). The plots for gauges 14 and 15 (Figs. 6 and 7) indicate that the flange strains produced at the aft missile hanger location during up loading of the missile are lower when the HDH snubber is fitted. The strain produced at gauge 16 (Fig. 8) is approximately the same for both types of snubber.

At the forward hanger the strain outputs from the lower flange (gauge 10 (d,e,f)) are up to 173 microstrain higher during up loading with the HDH snubber fitted to the launcher. The HDH snubbing system has clearly not reduced strains at the forward hanger by transferring load to the rear hanger (for this loading direction).

Down Loading

For the down loading case the plots for gauges 11 and 12 (Figs. 3 and 4) indicate that the HDH snubber does cause the upper flange of the launcher to carry more load at the aft missile hanger location. The compressive strains produced with the HDH snubber are about 100 microstrain higher than with the LAU-7/A snubber. The result for gauge 13 (Fig. 5) shows little change.

The results for gauges 9 (d,e,f) and 10 (d,e,f) (Table 3) at the forward hanger location show a negligible difference in strain carried by both the upper and lower launcher guide rail flanges during down loading between the LAU-7/A and HDH snubbers. To summarize the down loading case, the performance of the HDH snubbing system is inconclusive in that the forward hanger strains are the same as for the LAU-7/A snubbing system but the aft hanger strains are greater.

5.2 Dynamic Strain Surveys

Hawker De Havilland Snubber

The HDH snubber did not positively locate the missile under the action of dynamic loading. Thus the measured value of RMS strain varied as the missile altered its position in the launcher. The data acquisition system used involved sequential, not simultaneous,

measurement of the strain gauge readings, thus making the strain survey readings meaningless. Consequently no strains are presented for this condition.

LAU-7/A Snubber

The fitment of the LAU-7/A snubber allowed meaningful strain readings to be taken from the gauges fitted to the launcher. Some of the gauges were damaged during the process of changing snubbers and consequently gave zero strain output as shown in Table 2 which lists the strain outputs obtained.

Examination of the strain gauge outputs with the LAU-7/A snubber fitted to the launcher (Table 2) shows that overall the dynamic strains in the launcher guide rail flanges are very low. The only exception is Gauge 9 (d,e,f) on the upper launcher flange which shows strains of up to 165 microstrain. These higher strains can be explained by the presence of a crack at the base of the launcher guide rail flange in the region of strain gauge 9 (d,e,f). The crack was generated by the service the launcher saw on an F/A-18 aircraft prior to this test.

6.0 CONCLUSIONS

Dynamic Strain Surveys

It was not possible to carry out a meaningful dynamic strain survey with the HDH snubber system fitted to the launcher due to the time variant motion of the missile on the launcher rails.

The dynamic strains measured for the LAU-7/A snubber were generally not greater than 73 microstrain but the presence of a crack in the launcher rail flange at the forward hanger location resulted in strains of up to 165 microstrain in the flange at that location.

Static Strain Surveys

The static strain survey results show that the HDH snubber failed to reduce the strains seen by the launcher rails at the forward hanger location. In fact there was evidence of increased strain at this location for the up loading case.

Obtaining consistent static and dynamic strain surveys was difficult with either snubbing system. This is attributed to slippage of the missile relative to the launcher at the aft hanger location, resulting from ineffective snubbing action. Some anomalous strain results, such as from gauges 12 and 13 for up loading with the LAU-7/A snubbing system (Figs. 4 and 5), are perhaps attributable to this slippage.

Snubber Design

Neither design of snubber is regarded as satisfactory. The LAU-7/A snubber does not locate the missile very well on the launcher unless the missile is rocked to assist in the locking process ie the degree of snubbing is dependent on the diligence of the person

fitting the missile. The LAU-7/A snubber suffered high wear rates on the scissor action wedges during the dynamic strain survey and similar loads are seen by the launcher /missile assembly in service on the wing tips of the F/A-18 aircraft. The high wear rate degrades the ability of the snubber to lock the missile in place, i.e. the snubbing action rapidly degrades because the wedging action is lost.

The HDH snubber system was designed to hold the missile centrally on the launcher rails at the aft hanger location. It cannot, due to its design, provide any wedging action to hold the aft hanger bracket against the guide rail flanges to control the amount of load carried by the aft hanger. This limits its ability to reduce the loading at the forward hanger, and the static and dynamic strain surveys showed no evidence of any such reduction.

Perhaps the best way to prevent cracking of the launchers would be to devise a snubbing system at the aft hanger which positively locked the missile and transferred the moment load from the missile directly into the back of the launcher body rather than through the rails.

REFERENCES

1. Saunders, D.S.; Stimson, M.G. Unpublished work

2. Barter, S, Fractographic Examination of LAU-7 Launcher SN NO 0422B. ARL Materials Division Defect Assessment & Failure Analysis Report No. M61/92.

TABLE 1.

STATIC CALIBRATION LOADS

Up Loads	**Load Newtons**	**Down Loads**	**Load Newtons**
10%	-815	10%	+621
20%	-1630	20%	+1242
30%	-2445	30%	+1862
40%	-3260	40%	+2483
50%	-4075	50%	+3104
60%	-4890	60%	+3725
70%	-5705	70%	+4346
80%	-6520	80%	+4966
90%	-7335	90%	+5587
100%	-8150	100%	+6208

TABLE 2.

RMS STRAIN OUTPUTS FROM LAU-7/A LAUNCHER DYNAMIC LOADING LAU-7/A SNUBBER

Gauge No.	Output Microstrain
11a	23.7
11b	29.7
11c	30.4
11d	26.2
11e	20.8
11f	19.8
11g	24.4
11h	31.7
11i	35.2
11j	34.4
14a	1.8
14b	0
14c	2.2
14d	2.5
14e	2.7
14f	2.8
12a	15.7
12b	21.1
12c	22.0
12d	20.1
12e	15.2
12f	15.8
12g	17.8
12h	25.2
12i	29.2
12j	29.6
15a	11.5
15b	0
15c	10.7
15d	8.7
15e	6.8

Gauge No.	Output Microstrain
15f	6.2
13a	2.4
13b	2.2
13c	2.0
13d	1.3
13e	0.8
13f	0.7
13g	1.9
13h	3.5
13i	4.8
13j	6.2
16a	27.0
16b	26.0
16c	0
16d	16.6
16e	11.9
16f	9.3
9d	164.7
9e	133.9
9f	140.7
10d	46.0
10e	39.7
10f	40.3
1	35.2
2	47.9
3	8.9
4	13.4
5	2.8
6	5.2
7	29.6
8	6.2

TABLE 3

LAUNCHER STRAIN GAUGE OUTPUTS AT 100% LOAD

Launcher Strain Gauge Number	HDH Snubber Up Loads Gauge Output Microstrain	HDH Snubber Down Loads Gauge Output Microstrain	LAU-7/A Snubber Up Loads Gauge Output Microstrain	LAU-7/A Snubber Down Loads Gauge Output Microstrain
11a	-6	-206	82	-40
11b	-3	-288	89	-83
11c	-1	-311	82	-106
11d	3	-269	69	-100
11e	9	-205	55	-84
11f	12	-186	49	-80
11g	6	-231	44	-95
11h	-9	-324	28	-127
11i	-20	-358	5	-144
11j	-31	-346	-27	-146
14a	-238	-4	-357	-3
14b	-306	-2	-419	0
14c	-305	0	-404	4
14d	-257	1	-334	7
14e	-210	4	-276	11
14f	-193	3	-257	10
14g	-291	-3	-387	1
14h	-380	-8	-506	-8
14i	-412	-16	-555	-19
14j	-385	-23	-528	-28
12a	0	-110	-319	-36
12b	1	-158	-199	-57
12c	3	-174	-123	-67
12d	12	-150	-66	-58
12e	13	-110	-34	-44
12f	17	-106	-32	-46
12g	6	-137	-48	-56
12h	-8	-218	-109	-88
12i	-23	-261	-181	-107
12j	-36	-273	-258	-113
15a	-96	-1	-251	-5
15b	-121	0	-289	-3
15c	-139	-20	-281	-5
15d	-100	3	-221	1
15e	-77	5	-168	6
15f	-81	4	-166	10
15g	-143	-2	-266	-9
15h	-213	-10	-371	-34
15i	-259	-21	-427	-64
15j	-263	-26	-421	-86

TABLE 3 CONTINUED

LAUNCHER STRAIN GAUGE OUTPUTS AT 100% LOAD

Launcher Strain Gauge Number	HDH Snubber Up Loads Gauge Output Microstrain	HDH Snubber Down Loads Gauge Output Microstrain	LAU-7/A Snubber Up Loads Gauge Output Microstrain	LAU-7/A Snubber Down Loads Gauge Output Microstrain
13a	5	-7	-252	6
13b	6	-6	-152	8
13c	6	-3	-89	8
13d	6	0	-48	11
13e	5	0	-24	12
13f	-1	-6	-19	12
13g	6	-1	-51	9
13h	4	-16	-113	3
13i	3	-28	-186	-4
13j	2	-38	-257	-9
16a	-70	1	-112	-211
16b	-67	2	-108	-133
16c	-3	-5	0	0
16d	99	364	-54	-66
16e	-20	3	-28	-63
16f	-15	-1	-17	-62
16g	-38	-1	-68	-71
16h	-64	-5	-121	-102
16i	-83	-7	-158	-150
16j	-89	-9	-173	-208
9d	-18	-98	-5	-90
9e	-159	-504	-87	-465
9f	-203	-544	-118	-498
10d	-552	-132	-381	-109
10e	-495	-158	-329	-130
10f	-515	-177	-342	-147
1	-55	-442	80	-309
2	-338	-342	-302	-351
3	-294	-195	-191	-204
4	-461	-70	-258	-19
5	29	-23	36	-15
6	-18	24	-15	24
7	20	-177	24	-81
8	-161	8	-230	14

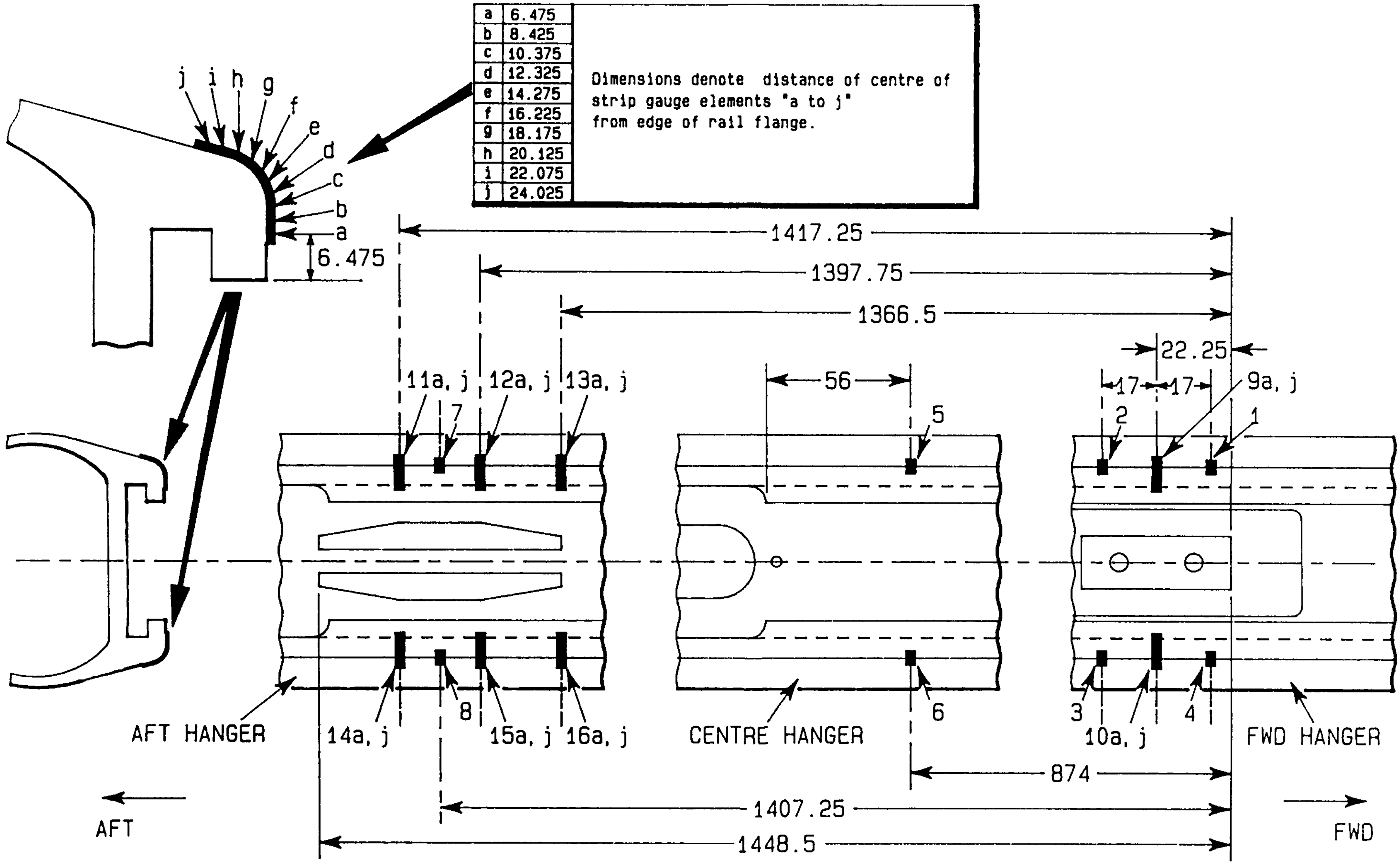

FIGURE 1. LAUNCHER STRAIN GAUGE POSITIONS

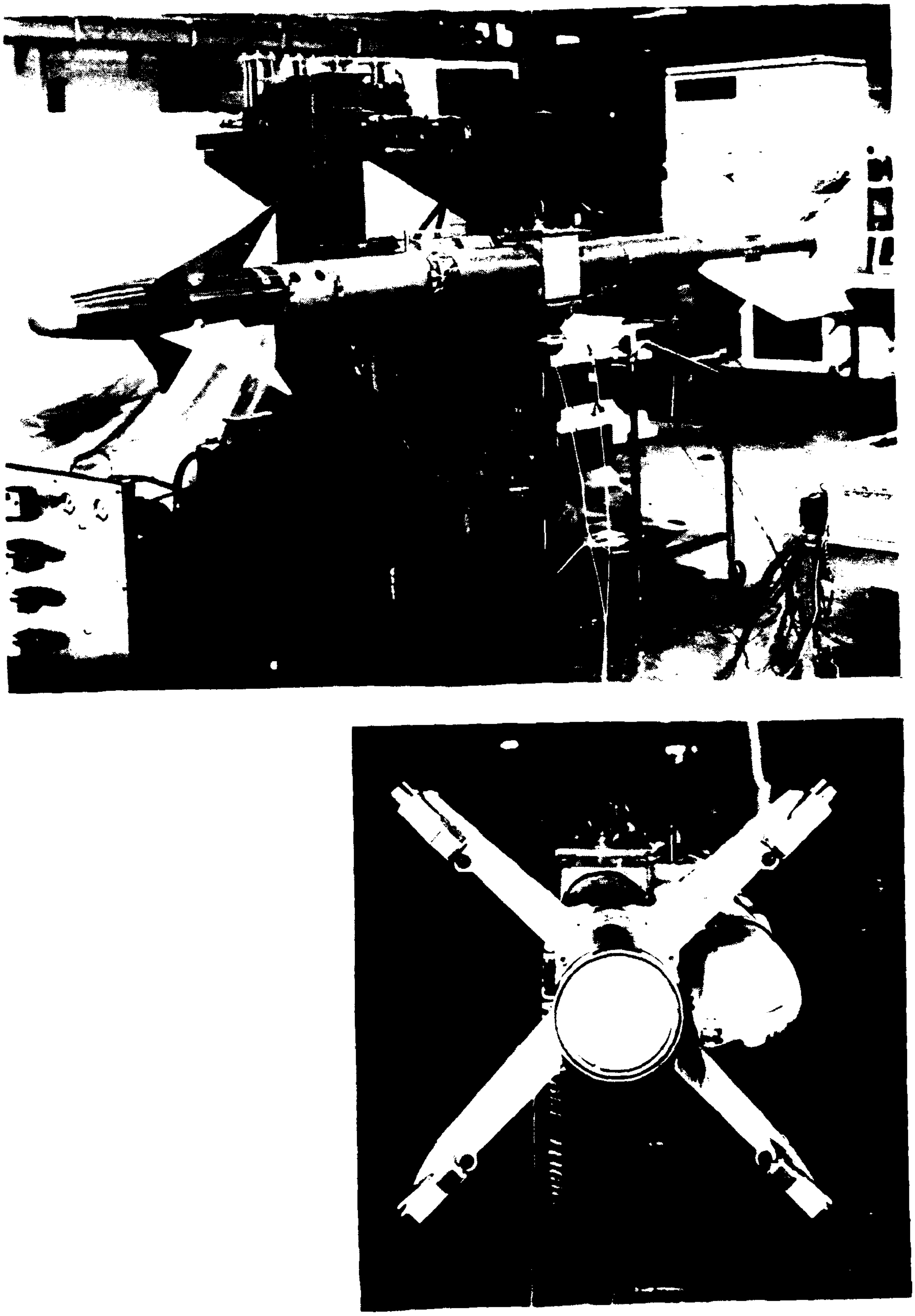

FIG. 2: LAUNCHER TEST RIG

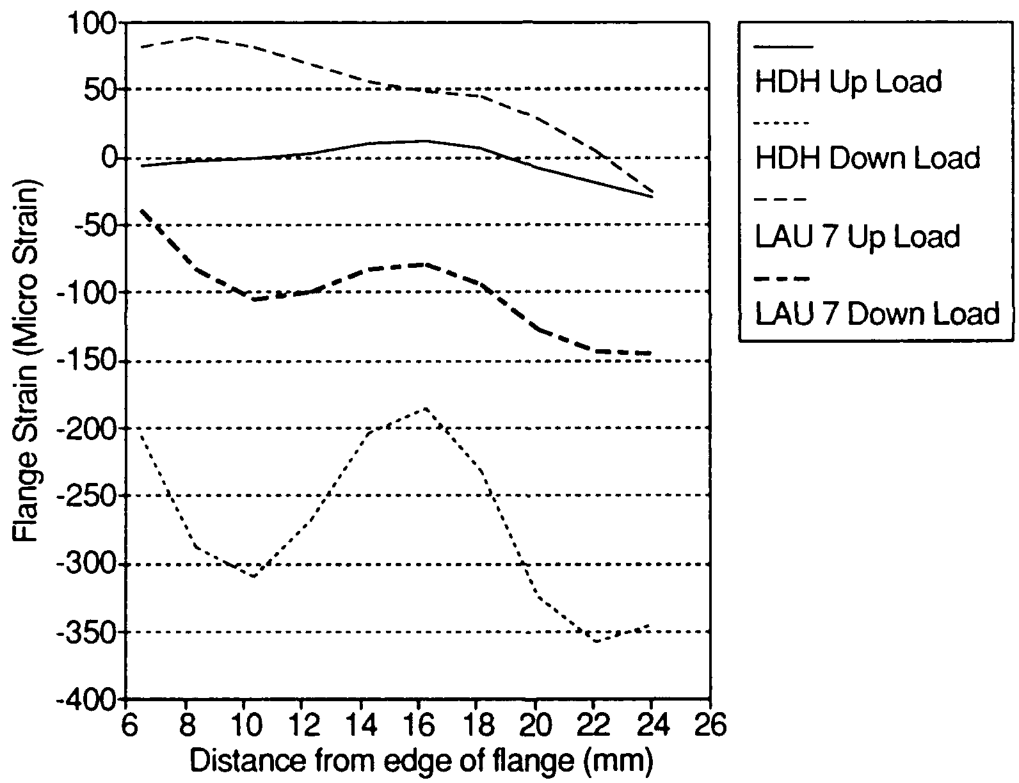

FIG. 3: UPPER FLANGE STRAIN DISTRIBUTION AT 100% LOAD
STRIP GAUGE 11 AFT HANGER LOCATION

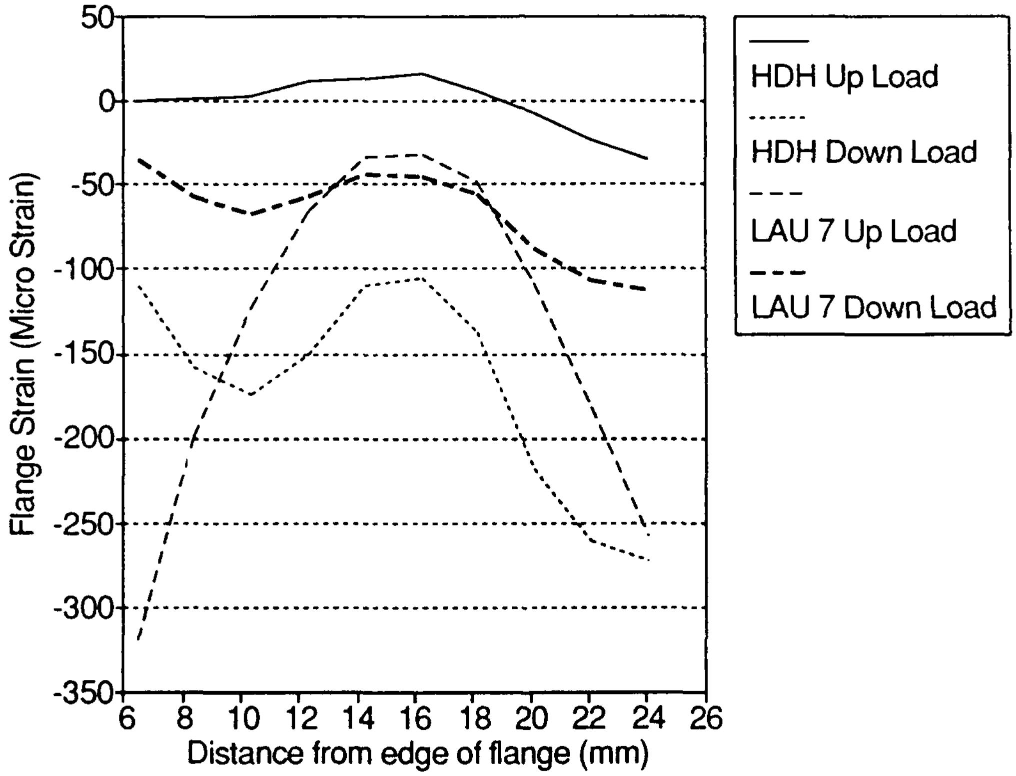

FIG. 4: UPPER FLANGE STRAIN DISTRIBUTION AT 100% LOAD
STRIP GAUGE 12 AFT HANGER LOCATION

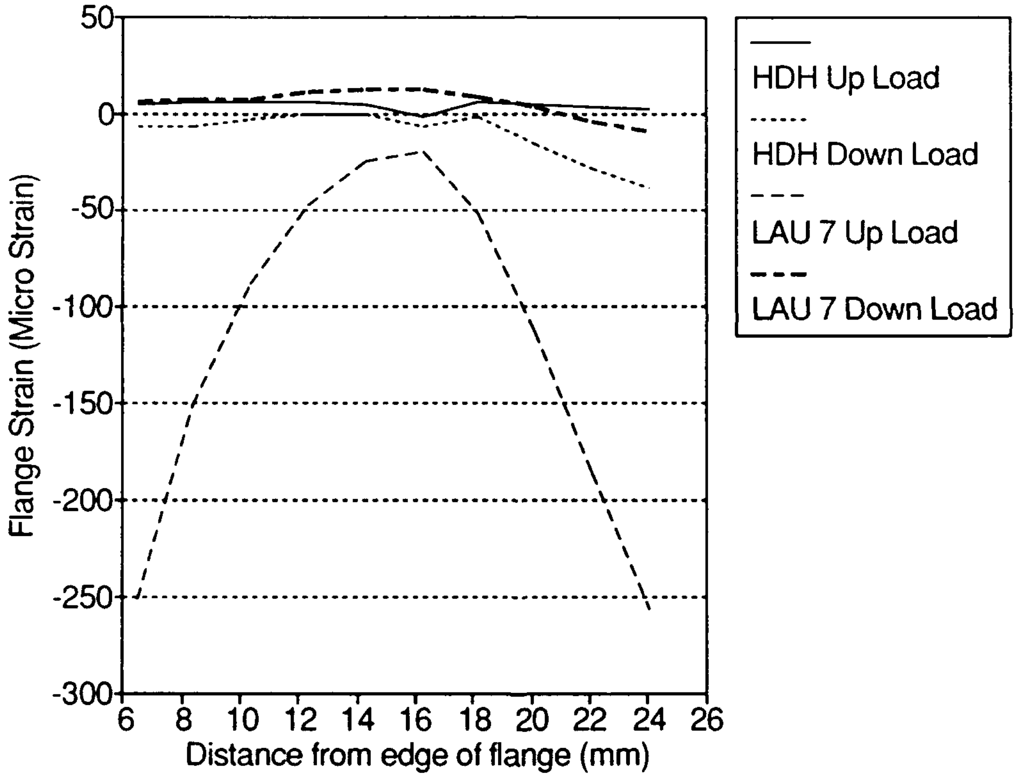

FIG. 5: UPPER FLANGE STRAIN DISTRIBUTION AT 100% LOAD
STRIP GAUGE 13 AFT HANGER LOCATION

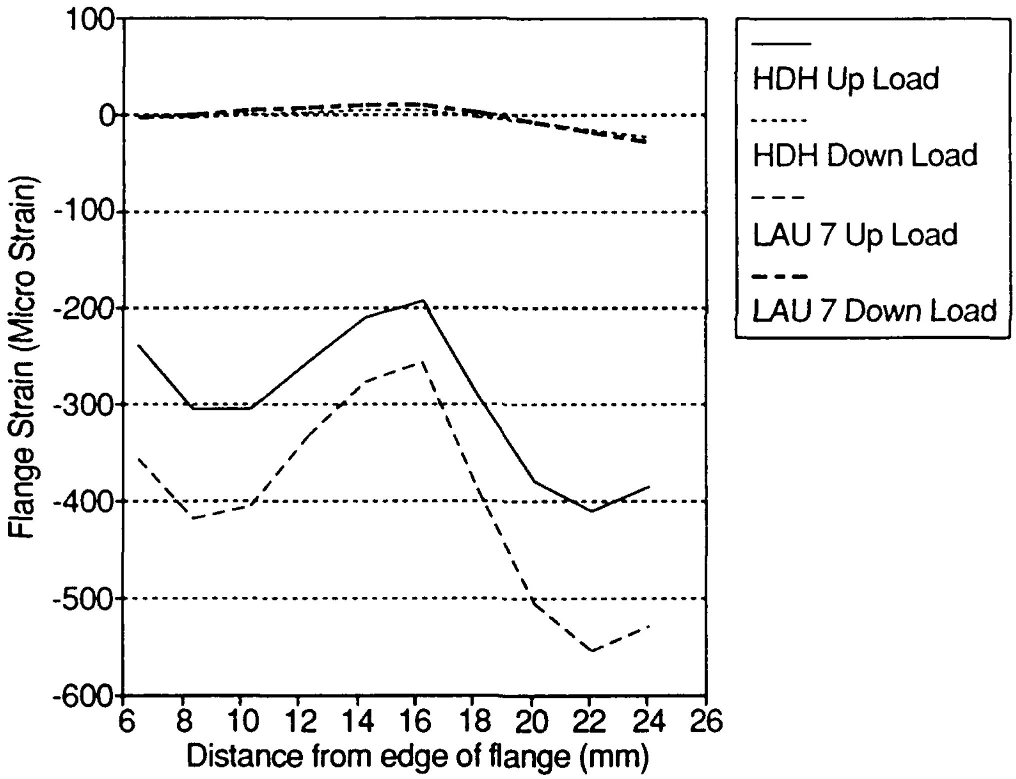

FIG. 6: LOWER FLANGE STRAIN DISTRIBUTION AT 100% LOAD
STRIP GAUGE 14 AFT HANGER LOCATION

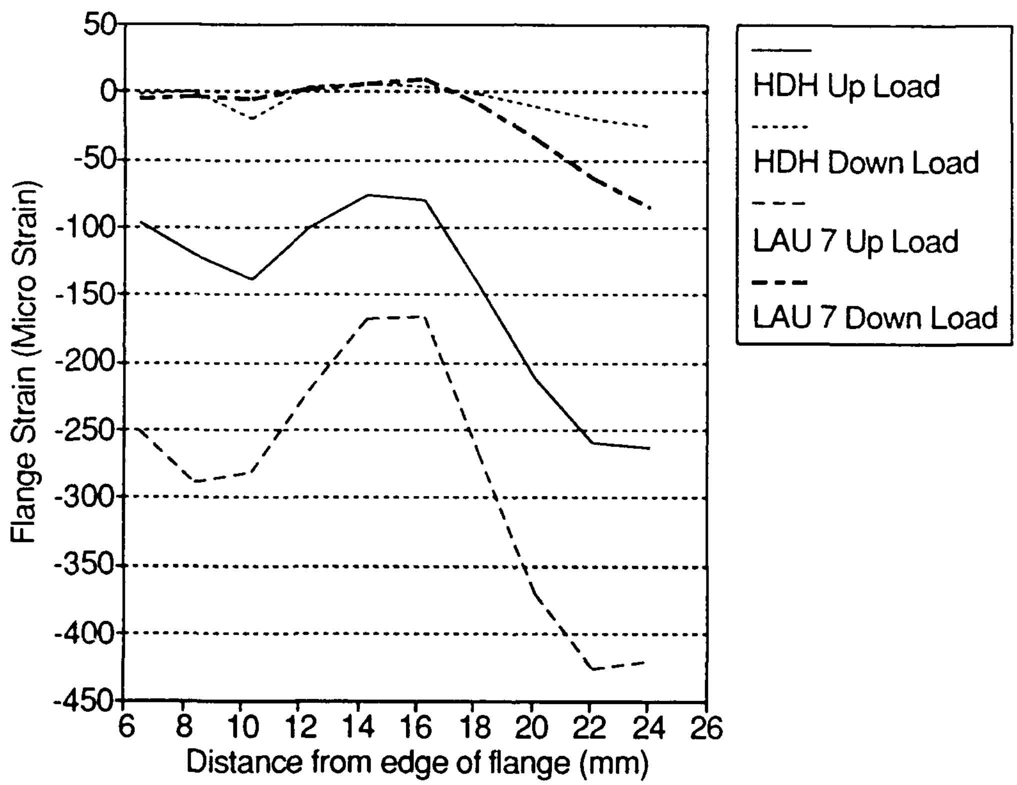

FIG. 7: LOWER FLANGE STRAIN DISTRIBUTION AT 100% LOAD
STRIP GAUGE 15 AFT HANGER LOCATION

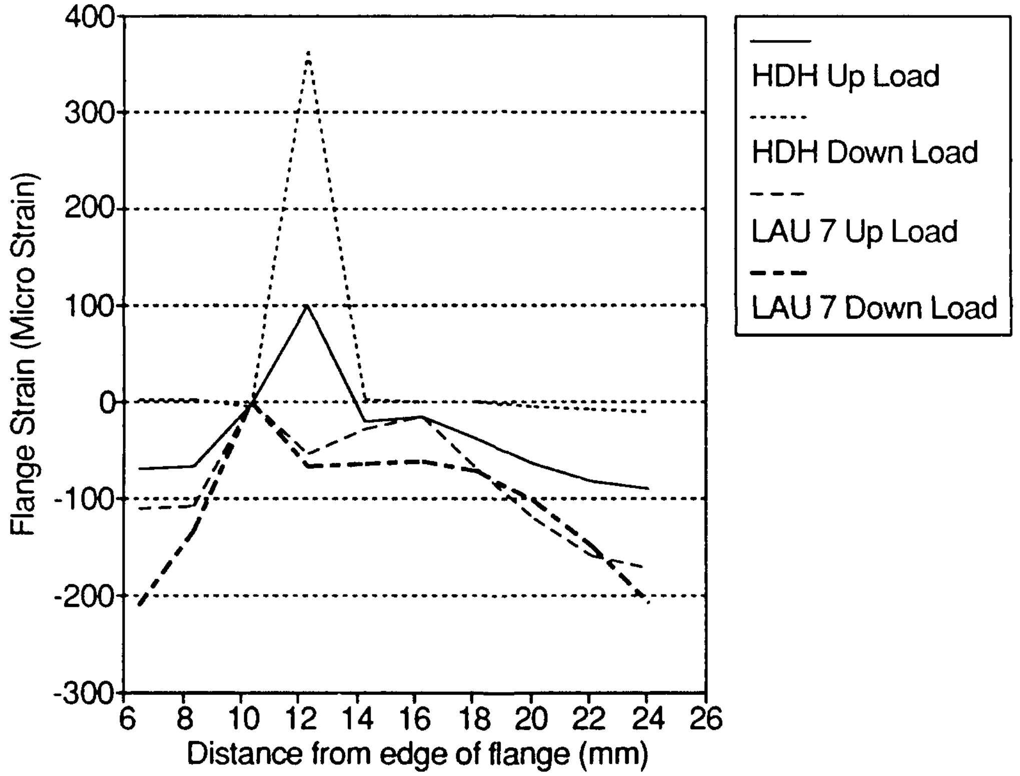

FIG. 8: LOWER FLANGE STRAIN DISTRIBUTION AT 100% LOAD
STRIP GUAGE 16 AFT HANGER LOCATION

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21 COMPUTER PROGRAMS USED

22 ESTABLISHMENT FILE REF.(S)

23 ADDITIONAL INFORMATION (AS REQUIRED)